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ABSTRACT

A computerized research technique for measuring the space utilization of public library facilities provides a behavioral activity and occupancy analysis for library planning purposes. The library space utilization (LSU) methodology demonstrates that significant information about the functional requirements of a library can be measured and displayed in a quantified form. It has primary importance as one of the first applications of computerized research techniques to the field of library facility planning. LSU has been designed to be utilized by library management, library building consultants, and architects. It measures activity or spatial relationships between functional divisions within the library as well as determining occupancy factors for the respective divisions of library staff and the public. The methodology provides a behavioral analysis of the library environment based on actual observation. This information can be cost-effectively displayed in a library's building program to enhance the probability of a more functionally efficient design. LSU is akin to behavioral studies such as tracking studies, time and motion studies, circulation pattern studies, space-time log studies, traffic flow studies and queuing theory studies.
(Author/RAA)

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LSU: THE LIBRARY SPACE UTILIZATION METHODOLOGY

by

RICHARD B. HALL

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ABSTRACT

The study presents a methodology for measuring the space utilization of public library facilities. It provides a behavioral activity and occupancy analysis of the library environment, and points the way toward future development of electronic library facility planning systems.

ACKNOWLEDGMENTS

The LSU methodology was developed at the University of Illinois as a post-master's degree research project and was subsequently pretested in fall 1977 at the Lincoln Library, the public library of Springfield, Ill. The author wishes to express his gratitude to the following individuals for their support and cooperation, without which this study would not have been possible: Dr. Herbert Goldhor, Graduate School of Library Science, UIUC; Michael Gorman, Director of Technical Services, UIUC Library; Walter Allen, Graduate School of Library Science, UIUC; Richard Blue, doctoral student, Graduate School of Library Science, UIUC; Marjorie Kiefer, Kay Weiss and Bruce Flanders, MLS students, UIUC; H. James Miller, Department of Architecture, UIUC; David Sides, Department of Architecture, UIUC; Candy and David Wilmont, computer programmers, UIUC; James Graham, architect of the Lincoln Library; Robert Wagenknecht, head librarian of the Lincoln Library; the staff of the Lincoln Library; and the University of Illinois Research Board.

INTRODUCTION

The Library Space Utilization (LSU) methodology demonstrates that significant information about the functional requirements of a library can be measured and displayed in a quantitative and graphic form. The primary importance of the LSU methodology is that it is one of the first applications of computerized research techniques in the field of library facility planning. This methodology has been designed to be utilized by library management, library building consultants and architects. It measures activity or "spatial" relationships between selected functional divisions within the library, as well as determines occupancy factors for the respective divisions, for both the library staff and the public.

The information gathered through the application of the LSU methodology provides a behavioral analysis of the library environment based on actual observation. This information can be cost-effectively displayed in a library's building program in a form that enhances the probability of a more functionally efficient design solution. The methodology is akin to a number of behavioral studies which attempt to measure facility use, such as tracking studies, time-and-motion studies, circulation pattern studies, space-time log studies, traffic flow studies, and queuing theory studies.

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LITERATURE SEARCH

In preparation for this study, an extensive literature search was conducted in an attempt to find descriptions of methodologies and studies which describe the behavior or "activities" of individuals in a particular building type. This involved searching the numerous catalogs, indexes and abstracts of the University of Illinois Library, including the three on-line data bases of ERIC, INSPEC and *Engineering Index*. The literature search was not limited to descriptors in the library and information science field, but also included architectural, engineering, behavioral psychology, and computer science terms.

The development of the methodology was based on significant previous efforts to show graphically library spatial relationships in the form of bubble diagrams,[1] and schematics illustrating a network of interconnected spaces through the use of arrows.[2] The present methodology stemmed most directly from Neustadter's *Study of Public Traffic Flows in the Library*,[3] which described measured circulation patterns of library patrons in eight selected areas within the public library of Glendale, Calif. The eight areas of the library were the entrance, the popular library, the children's library, the return area, the charge area, the reader's service area, the bound periodicals section, and the newspaper/periodical reading room. Unfortunately, there is no description of the methodology used in the program. Further, the director of the library reports that the study was never published, and a copy of it is no longer in existence.

PROCEDURE FOR DATA COLLECTION

The first step in applying the methodology was to obtain and analyze carefully a set of floor plans for the library. The following 18 divisions of the library's organization were defined in terms of physical spaces on the plans:

ADM—Administrative Services
AVR—Audiovisual and Recreation Services
BRS—Browsing Services
CAT—Catalog
CCS—Circulation and Control Services
CHS—Children's Services
EXT—Extension Services
FIC—Fiction Collection
NFC—Nonfiction Collection
PBE—Public Entry and Exit
PER—Periodicals Services
PMS—Public Meeting Services
RFC—Reference Collection
RFS—Reference Staff Services
SPC—Special Collections
STE—Staff Entry and Exit
STS—Staff Services
TCS—Technical Services

Figures 1, 2 and 3 show the first, second and third floor plans with the mnemonic codes for each division location therein. These divisions were determined with the cooperation of the professional staff of the library during several conferences. The importance of this selection of divisions will be demonstrated later under a discussion of the clustering technique. Some may argue with the specific divisions chosen, so it is significant to note that the methodology will work equally well regardless of the pattern of the divisions.

Because of the design of the methodology—the use of observation as the data collection technique—it was necessary that the staff be aware of observation, but that it be unobtrusive

FIGURE 1. GROUND FLOOR PLAN

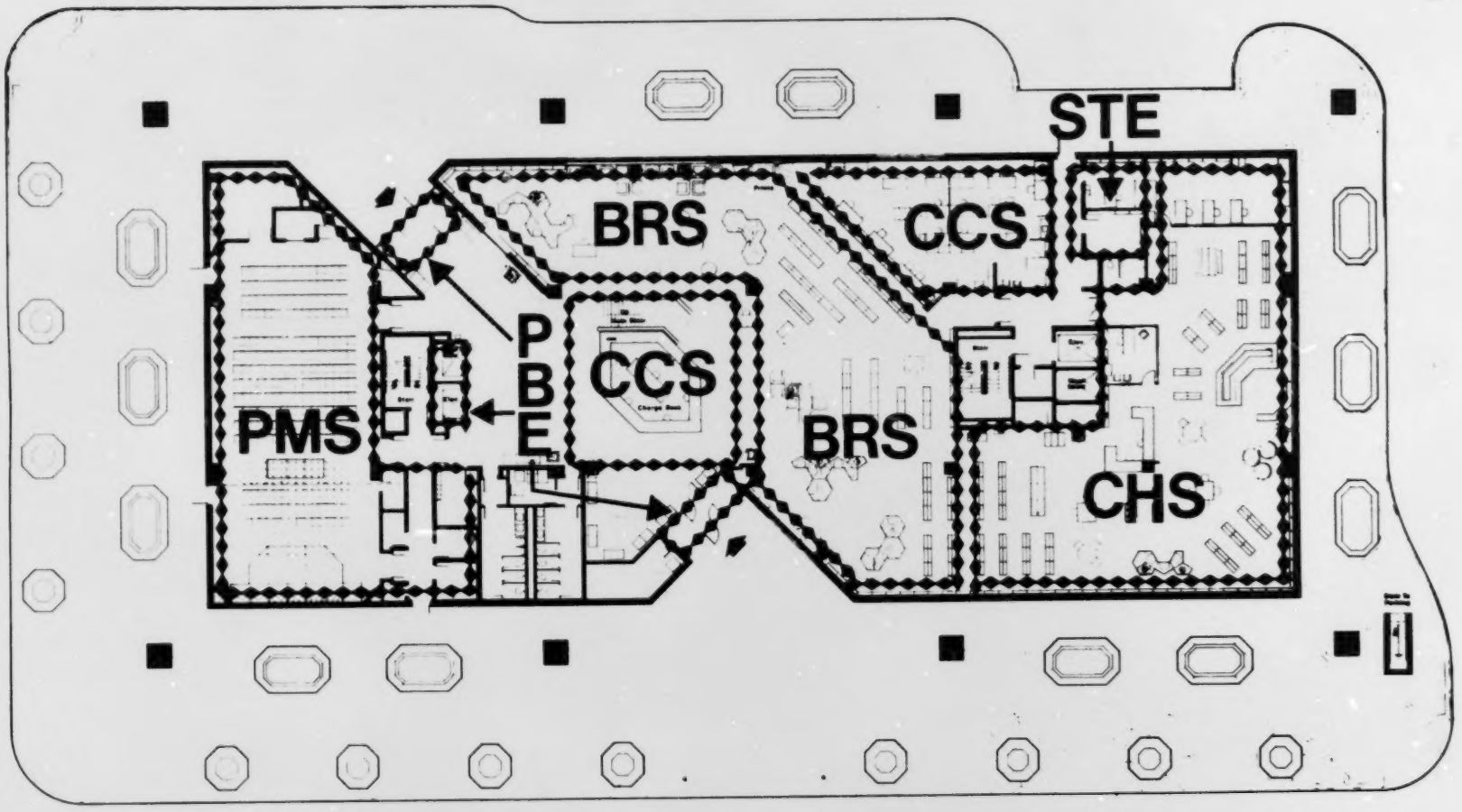
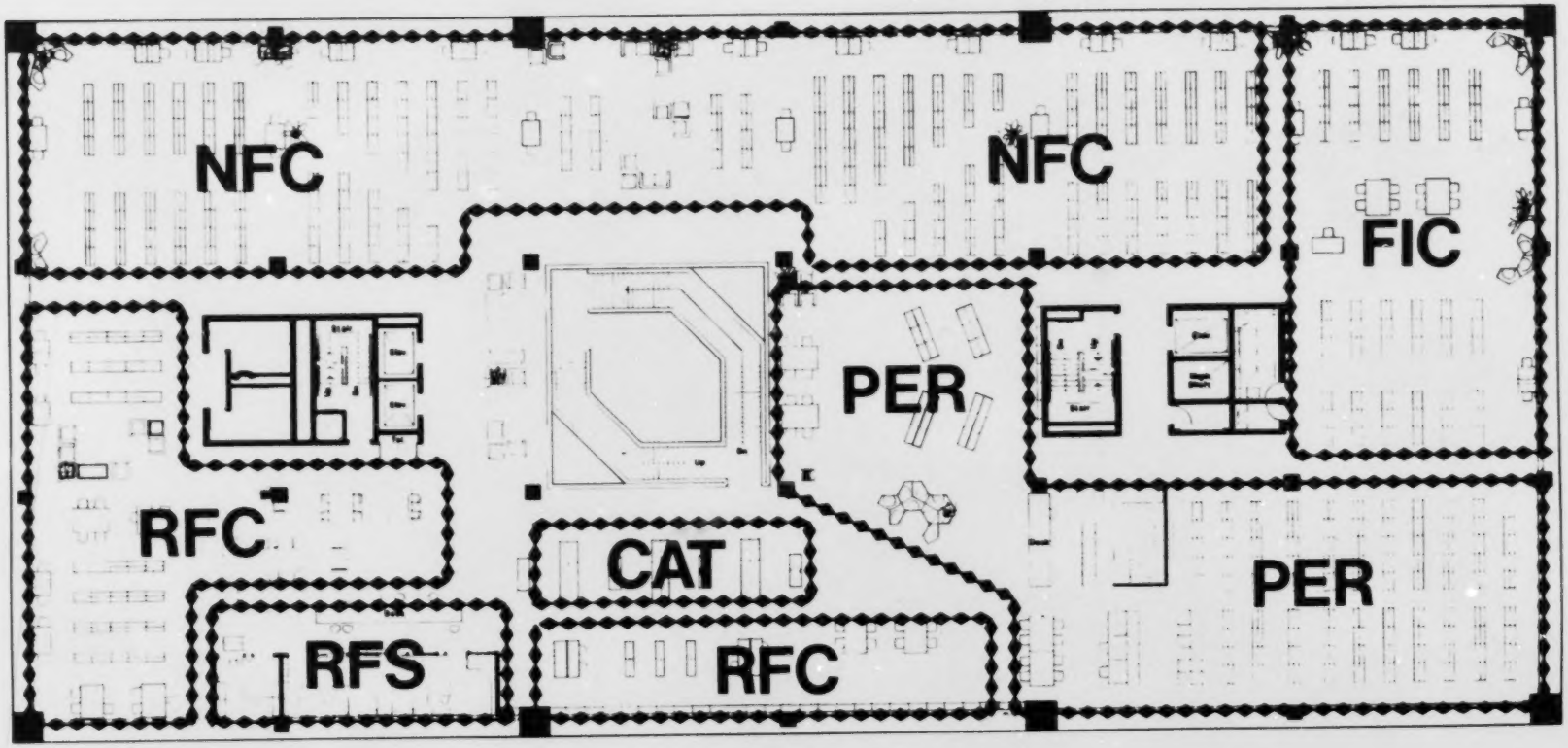
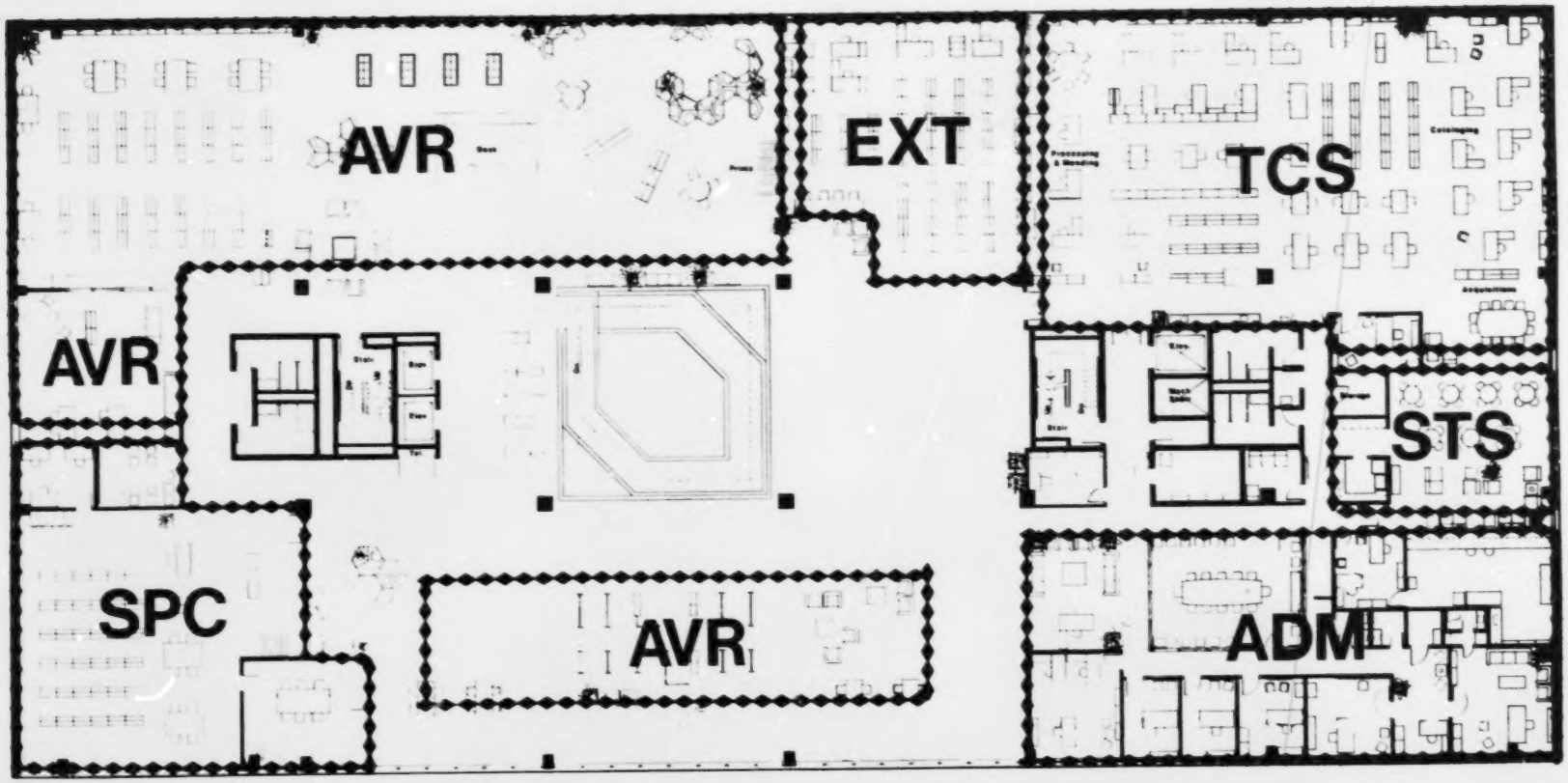


FIGURE 2. SECOND FLOOR PLAN



Second Floor Plan

FIGURE 3. THIRD FLOOR PLAN



to the public. Since the staff knew that they were being observed, to prevent bias they were assured that the study was not a job performance evaluation, and that the study results could in no way be used to threaten their job security. Careful preparation of the staff was important to the success of the study so that no significant problems with the staff feeling apprehensive during the data collection would affect the results.

The observation of the public was made in an unobtrusive manner so as not to bias the patron and change his activity pattern. Although this may seem a bit unethical to some, the fact is that the study in no way interferes with the privacy of the individual because the results of the observations cannot by any stretch of the imagination harm the individuals observed. The observer does not interfere or interact with the patron. For a maximum of ten minutes, he simply observes where a person goes, and how long he or she spends in the divisions visited.

To accomplish the data collection, the observer was equipped with a notebook to which was clipped a data collection form (Figure 4), a randomized list of the divisions, and a set of miniaturized floor plans with the divisions clearly delineated, until he became so familiar with the buildng layout that they were no longer needed. The observer also wore a digital wristwatch for use in recording the minutes and seconds during the time trials.

To start a data collection trial, the observer stations himself in a division selected from a random list of divisions and records its code along with the starting time. Next, the observer records the number of patrons and staff present, if any, and then waits for a maximum of five minutes, or until the first person leaves the division. If someone leaves within five minutes, the observer records the time the first person left and whether he or she was patron or staff. The observer then records the time the individual enters the next division and that division's code letters.

This sequence is repeated until the observed individual leaves the building or until the maximum observation time of ten minutes is up. The observer then repeats the procedure by picking another division from the random list and starting a new time trial elsewhere in the library. After an adequate number (1600 interactions) of these trials were run, the results began to show major and, to some extent, general trends in the "traffic patterns" of individuals using the library environment.

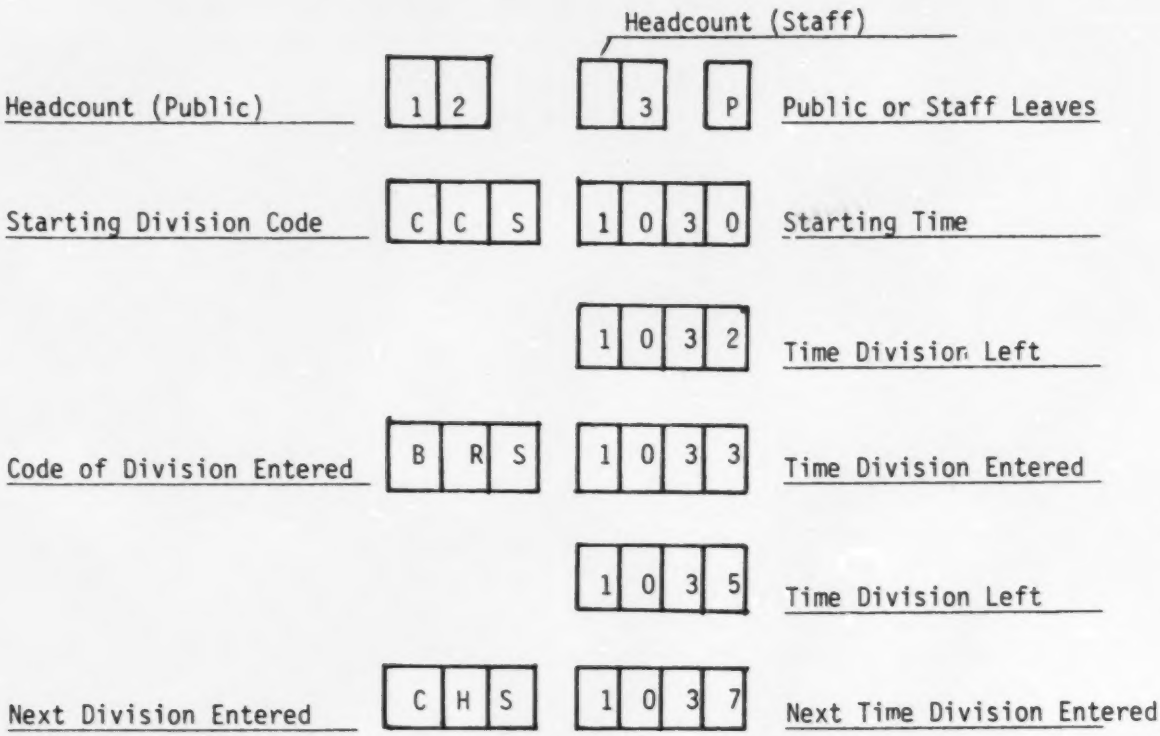
RESULTS

Activity Analysis

The cumulative results of the time trials were processed using a computer program which allowed for numerous displays of the data gathered. Table 1 shows a portion of the numerical results for the 18 divisions in the form of ranked interaction percentages. It should be noted that the ranked interaction percentages can be computed in two ways: nonadditive and additive.

The nonadditive method bases its percentage computation on the individual columns in Table 1 (public, staff and combined), which means that traffic flow diagrams could be constructed for each individual subject status, i.e., one for the public only, one for the staff

FIGURE 4. DATA COLLECTION FORM



only, and one for the two of them combined. The additive method bases its percentage computation on the combined column only; that is, the percentages for the staff and public columns do not equal 100% individually, but do so when added together. The additive method of tabulation is the most significant because it represents the natural weighting of staff circulation in relative balance to public circulation for any interaction sequence.

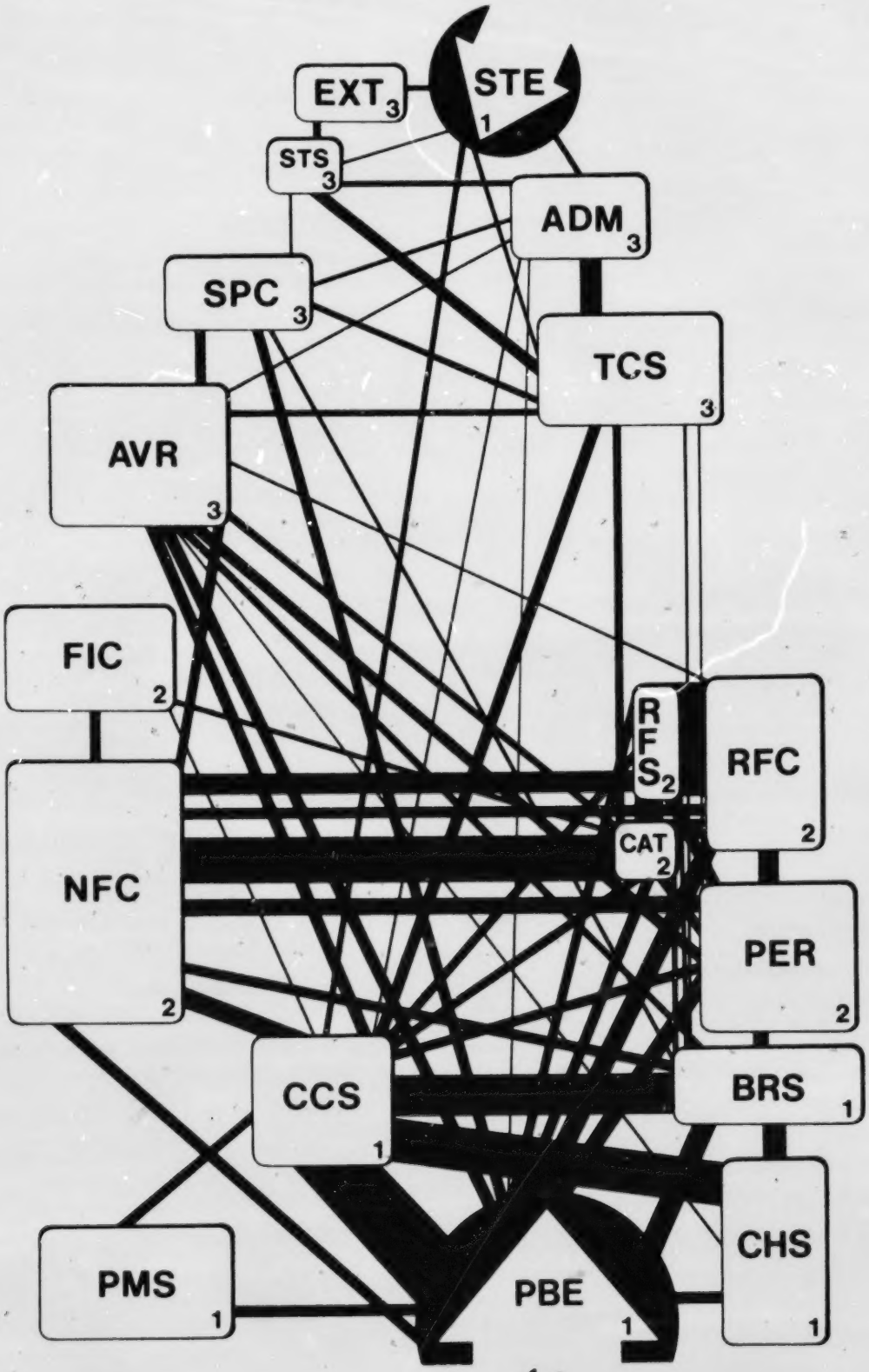
This kind of information allows the designer to understand better the nature of the traffic patterns, as can be seen in the case of the strongest interaction sequence (15.5%) between the reference staff services and the reference collection divisions. By adding the staff's 12.5% and the public's 3.0%, the total equals the combined interaction percentage of 15.5%. This can be done for all of the interaction sequences (with only a 0.1% variation for rounded-off decimals).

The numerical results of the activity interactions can be best visualized and interpreted in their graphic form (Figure 5) as "spatial relationships" of the divisions. By examining the

TABLE 1. RANKED INTERACTION PERCENTAGES

PUBLIC		STAFF		COMBINED	
PBE CCS	9.2	RFS RFC	12.5	RFS RFC	15.5
CAT NFC	5.3	RFS CAT	2.9	PBE CCS	9.2
CCS BRS	4.0	CCS CHS	2.4	CAT NFC	6.1
PBE BRS	3.0	ADM TCS	2.3	CCS BRS	5.2
RFS RFC	3.0	RFS NFC	1.7	CCS CHS	4.8
CCS CHS	2.4	TCS STS	1.3	RFS CAT	3.9
PBE PER	1.9	CCS BRS	1.2	PBE BRS	3.1
RFC PER	1.7	CCS NFC	1.0	RFS NFC	2.5
NFC PER	1.6	CCS TCS	.8	ADM TCS	2.4
PBE RFC	1.5	CAT NFC	.8	CCS NFC	2.2
BRS CHS	1.3	RFS PER	.6	RFC PER	2.0
CCS NFC	1.2	AVR TCS	.6	PBE PER	1.9
RFC CAT	1.2	CCS STS	.5	BRS CHS	1.7
PBE NFC	1.1	RFC CAT	.5	RFC CAT	1.7
PBE AVR	1.1	RFC NFC	.5	NFC PER	1.6
RFS CAT	1.1	AVR SPC	.5	PBE RFC	1.6
BRS PER	1.0	CAT TCS	.5	RFS PER	1.4
RFS NFC	.9	TCS STE	.5	RFC NFC	1.4
RFC NFC	.9	CCS STE	.4	TCS STS	1.3
CAT PER	.9	BRS CHS	.4	BRS PER	1.3
NFC AVR	.9	SPC TCS	.4	PBE NFC	1.1
PBE CHS	.8	ADM STS	.4	PBE AVR	1.0
PBE RFS	.8	EXT STS	.4	PBE RFS	.9
RFS PER	.8	CCS ADM	.3	CCS AVR	.9
CCS AVR	.7	BRS TCS	.3	CAT PER	.9
BRS NFC	.7	NFC FIC	.3	AVR SPC	.9
PER AVR	.7	PER TCS	.3	PBE CHS	.9
PBE PMS	.6	AVR ADM	.3	NFC FIC	.9
CCS RFS	.6	SPC ADM	.3	NFC AVR	.9
CCS PMS	.5	ADM STE	.3	PER AVR	.9
CHS AVR	.5	EXT STE	.3	CCS TCS	.8
CAT AVR	.5	STS STE	.3	BRS NFC	.7
NFC FIC	.5	CCS AVR	.2	PBE PMS	.6
PBE CAT	.5	BRS PER	.2	CCS RFS	.6
PBE SPC	.5	BRS SPC	.2	AVR TCS	.6
CCS CAT	.5	RFS TCS	.2	PBE SPC	.5
CCS PER	.4	RFS STS	.2	CCS PMS	.5
BRS AVR	.4	RFC PER	.2	CCS STS	.5
CAT FIC	.4	SPC STS	.2	CHS AVR	.5
AVR SPC	.4	EXT TCS	.2	CAT AVR	.5
BRS RFS	.3	PBE CCS	.2	ADM STE	.5
BRS CAT	.3	PBE RFS	.2	PBE CAT	.5
BRS PMS	.2	PBE ADM	.2	CCS CAT	.5
CHS NFC	.2	CCS FIC	.2	BRS AVR	.5
RFC AVR	.2	CCS EXT	.2	CAT TCS	.5
ADM STE	.2	RFS AVR	.2	SPC ADM	.5
PBE FIC	.2	PER AVR	.2	TCS STE	.5
PBE ADM	.2	AVR STE	.2	CCS PER	.4
CCS RFC	.2	PBE BRS	.1	CCS STE	.4
CCS SPC	.2	PBE CHS	.1	BRS RFS	.4

FIGURE 5. Activity Interactions



diagram, it is easy to see why the librarian's task of explaining to the designer the spatial relationships of the library has not been an easy one. The variety and relative strengths of interactions between the divisions are extremely complex and difficult to explain in a verbal, nonquantitative form.

The spatial diagram illustrates the most important interactions' strengths, with easy reference to their relative degree of significance (i.e., thickness of line). Further, the diagram represents the actual square footage of each division, and the number in each divisional space indicates the floor level that division occupies in the actual building. This diagram is in essence a two-dimensional behavioral network analysis of the library environment. It provides the designer with a clear, concise systematic link analysis of the various organizational divisions of the Lincoln Library.

There is much an artist could do to refine and improve the diagram further. For example, ultimately one could show not only the additive breakdown for each subject category (public and staff) between each pair of divisions by using a solid line for one category and a broken line for the other, but also the direction of the flow for each category by the use of arrows. It should be obvious to the reader that this type of spatial diagrammatic analysis is just what the designer of a library building would like to have at the beginning of the design process. The designer's problem is one of synthesizing the functional network of spaces into a real library building. This task necessarily calls for some trading off of proximity priorities, because when given a real site problem and a limited budget, it is usually impossible to satisfy 100% of the functional requirements. The proximity priorities can best be understood by comparing the spatial diagram and the ranked interaction percentages table. Upon close examination, it becomes obvious that there are essentially two nodes or "clusters" of activity.

Clustering

The methodology supports a clustering mechanism which can produce interaction percentages and spatial diagrams for newly created "clustered" divisions. The clustering is simply the collapsing of two or more of the divisions into one logical cluster, i.e., PBE and CCS into PEC; and RFS, RFC, and CAT into REF.

Clustering not only provides a new way of looking at the data, it also makes the new spatial diagram easier to read because it reduces complexity by greatly simplifying the relationships (Figure 6). Even though it is beyond the scope of the present study, it is easy to see from the clustered diagram that an in-depth analysis of all the newly created relationships could be performed for the clustered data as well as for the original data.

Relative Interaction Matrices

Figure 7 is a relative interaction matrix which shows the combined total percentages for all interactions for the original data. This matrix is essentially the same information as that presented in the combined column of Table 1, only displayed differently. The interaction matrix allows the designer to scan any division and find its percentage of interaction with any other division quickly.

The matrix is read in the following manner. If, for example, one wanted to know the interaction percentage for the divisions CCS and CHS, either of the divisions could be

FIGURE 6. CLUSTERED ACTIVITY INTERACTIONS

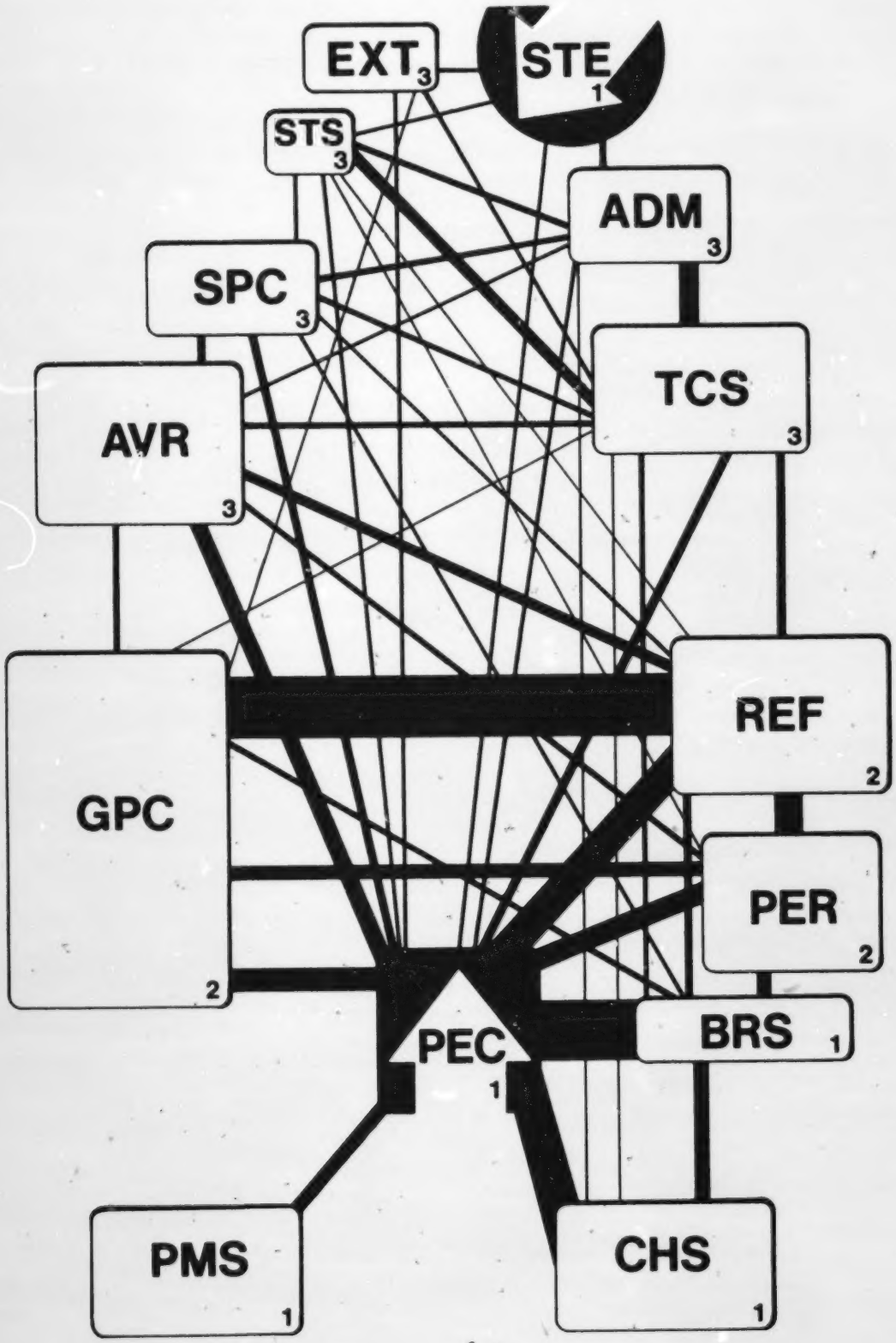


FIGURE 7. COMBINED TOTAL PERCENTAGES

| | | |

located in the left-hand column and, reading diagonally in the direction of the other division, the value (in this case, 4.8) of the interaction percentage is found in the corresponding division's diagonal column. Similar interaction percentage matrices for the various forms of percentage computation of the staff and public categories (for both the original and clustered data) are available, although they are not presented here.

The methodology also supports relative interaction matrices which show the total raw data for the combined, public and staff circulation categories, as well as the direction of interaction of the circulation flow (Figures 8, 9, and 10). In the case of the combined category, Figure 11 is the "forward" raw data matrix, and is read from the top down, while Figure 12 is the "backward" (reverse) matrix, and is read from the bottom up. For example, of the 118 individuals who traveled between the public entry and exit and the circulation and control services divisions, 14 of them went from PBE to CCS and 104 went from CCS to PBE. This type of information can be very helpful in planning the interior design, especially with respect to determining the signs for the library.

Major Activity Relationship

The primary activity cluster in the library encompasses the divisions of circulation and control services and public entry and exit. In fact, the second highest combined interaction percentage (9.2) is between these two divisions themselves. To most librarians this is not surprising, and some may feel that the study goes to great lengths to prove the obvious. However, few could have quantitatively stated how significant this particular relationship is in comparison to the spatial relationships of all the other divisions of the library. The methodology provides an overview of all the spatial relationships of the library along with specific information about the nature of each individual relationship.

The circulation division also has very strong relationships with the browsing services and the children's services division, at 5.2% and 4.8%, respectively. The first of these relationships is caused by the fact that the browsing division houses a large proportion of the most recent publications in the library. Also, it is located on the first floor near the public entrance and the circulation division. This finding supports Goldhor's research on the effects of prime display location in public libraries.[4] The second relationship, with children's services, is caused by that division's location on the first floor along with the fact that the Lincoln Library has a single circulation desk.

The browsing services division has a high degree of interaction not only with public entry and exit (3.1%), but also with children's services (1.7%). This is caused by adults entering the library and either going directly to the browsing services division or dropping off their children and then browsing while waiting for them. This activity was foreseen by Lincoln Library administration and its designer, so the two spaces are physically adjacent.

Another significant interaction in this activity cluster is between the circulation division and the nonfiction collection, at 2.2%. More patrons (1.2%) travel between these two divisions than staff (1.0%), but not as many more as might have been guessed. Of those public individuals who traverse the distance, seven times as many are going from the nonfiction collection to the circulation division as the reverse. This is presumably the activity of selecting materials in the nonfiction collection and then proceeding to the circulation desk to check them out before leaving the library. Of those staff members who

FIGURE 8. Total Raw Data for Combined Category

PUBLIC ENTRY & EXIT	PBE	118																			
CIRC & CONTROL SERV	CCS		39																		
BROWSING SERVICES	BRS	66		8																	
PUBLIC MEETING SERV	PMS		7		11																
CHILDREN'S SERVICES	CHS	3		61		12															
REFERENCE STAFF SERV	RFS		22		8		20														
REFERENCE COLLECTNS	RFC	1		4		2		6													
GENERAL CATALOG	CAT		1		3		6		14												
NON-FICTION COLLECTN	NFC	0		1		4		28		2											
FICTION COLLECTION	FIC		0		0		9		3		24										
PERIODICALS SERVICES	PER	198		1		0		1		5		13									
A-V & RECREATNL SERV	AVR		50		3		0		16		12		7								
SPECIAL COLLECTIONS	SPC	22		32		0		0		6		2		3							
ADMIN SERVICES	ADM		18		1		1		1		4		4		0						
EXTENSION SERVICES	EXT	78		2		8		4		0		0		2		1					
TECHNICAL SERVICES	TCS		5		25		3		0		0		0		10		0				
STAFF SERVICES	STS	11		12		4		1		1		0		4		7		0			
STAFF ENTRY/EXIT	STE		21		5		3		0		0		0		0		5				
		2		11		0		0		0		1		0		1					
			0		1		0		0		3		0		0						
		11		0		0		0		0		3		0							
			0		0		1		6		0		1								
		12		0		0		1		0		0									
			4		0		1		0		0										
		6		0		4		0		0											
			0		8		1		0												
		0		5		1		1													
			30		3		2														
		3		5		0															
			5		6																
		17		5																	
			6																		
		4																			

FIGURE 9. Total Raw Data for Public Category

PUBLIC ENTRY & EXIT	PBE	116																			
CIRC & CONTROL SERV	CCS		38																		
BROWSING SERVICES	BRS	53		8																	
PUBLIC MEETING SERV	PMS		7		10																
CHILDREN'S SERVICES	CHS	3		29		10															
REFERENCE STAFF SERV	RFS		17		8		20														
REFERENCE COLLECTNS	RFC	1		3		2		6													
GENERAL CATALOG	CAT		1		3		6		14												
NON-FICTION COLLECTN	NFC	0		1		4		17		2											
FICTION COLLECTION	FIC		0		0		9		1		24										
PERIODICALS SERVICES	PER	38		1		0		1		5		13									
A-V & RECREATNL SERV	AVR		13		3		0		13		9		6								
SPECIAL COLLECTIONS	PC	15		11		0		0		5		2		1							
ADMIN SERVICES	ADM		11		0		1		1		1		0		0						
EXTENSION SERVICES	EXT	68		2		10		4		0		0		0		0					
TECHNICAL SERVICES	TCS		5		22		1		0		0		0		0		0				
STAFF SERVICES	STS	7		11		3		0		0		0		0		0		0			
STAFF ENTRY/EXIT	STE		21		5		2		0		0		0		0		0				
		2		11		0		0		0		0		0		0					
			0		1		0		0		0		0		0						
		9		0		0		0		0		0		0							
			0		0		0		0		0		0								
		5		0		0		0		0		0									
			0		0		0		0		0										
		1		0		0		0		0											
			0		0		0		0												
		0		0		0		0													
			1		0		0														
		0		0		0															
			0		3																
		0		0																	
			0																		
		0																			

FIGURE 10. TOTAL RAW DATA FOR STAFF CATEGORY

PUBLIC ENTRY & EXIT	PBE	2																				
CIRC & CONTROL SERV	CCS		1																			
BROWSING SERVICES	BRS	13		0																		
PUBLIC MEETING SERV	PMS	0	0		1																	
CHILDREN'S SERVICES	CHS	0	5	32		2																
REFERENCE STAFF SERV	RFS	0	0	1	0		0															
REFERENCE COLLECTNS	RFC	0	0	0	0	0		0														
GENERAL CATALOG	CAT	0	0	0	0	0	11		0													
NON-FICTION COLLECTN	NFC	160	0	0	0	0	0	2		0												
FICTION COLLECTION	FIC		37	0	0	0	0	3	0		0											
PERIODICALS SERVICES	PER	7		21	0	0	0	1	3	0		1										
A-V & RECREATNL SERV	AVR		7		1	0	0	0	3	0	1		2									
SPECIAL COLLECTIONS	SPC	10		0		8	0	0	0	0	0	2		1								
ADMIN SERVICES	ADM		0		3		2	0	0	0	0	0	10		0							
EXTENSION SERVICES	EXT	4		1		1		1	1	0	0	4		7		0						
TECHNICAL SERVICES	TCS		0		0		1	0		0	0		0		5							
STAFF SERVICES	STS	0		0		0		0	0	1		0		1								
STAFF ENTRY/EXIT	STE		0		0		0		0		3		0		0							
		2		0		0		0		3		0										
			4		0		1		0		0		1									
		5		0		4		0		0												
			0		8		1		0													
		0		5		1		1														
			29		3		2															
		3		5		0																
			5		3																	
		17		5																		
			6																			
		4																				

FIGURE 11. FORWARD RAW DATA

| | | |

FIGURE 12. BACKWARD RAW DATA

| | | |

traverse the same distance, twice as many go from the circulation division to the nonfiction collection as the reverse. This is the activity of reshelving the material checked out from the nonfiction collection.

Both the circulation and the public entry and exit divisions show a relationship with the public meeting services division. Although this relationship is not relatively strong, it is not unusual for designers to locate public meeting rooms on the first floor of libraries. The reason this is so frequently done is that the public meeting division does not have a particularly significant relationship with any of the other divisions. Because of the usual limitations on the size of library sites and the importance of locating on the first floor those divisions most likely to improve the facility's functional performance, it is very important not to locate divisions there which do not have a strong circulation interaction with the public entry and exit division. In larger buildings, it is not an insoluble architectural problem to locate the public meeting services on a secondary level, adding a connecting link of an elevator and providing a way of closing the library off from these spaces when the library is closed and the meeting rooms are still in use.

The rest of the interaction relationships for this activity cluster are scattered over the remaining divisions. None of the relationships are very strong by themselves, but they may become quite significant when the two divisions are clustered.

The second activity cluster encompasses the divisions commonly known to contain the reference function of the library: the catalog, the reference collection, and the reference staff services. As previously mentioned, the most significant interaction relationship in the whole library lies here, between the reference staff services and the reference collection (15.5%). A very high percentage (12.5) of this interaction is composed of staff activity. Most reference librarians know that they do a good deal of circulating within the library each day, but it seems unlikely that anyone would have guessed it was this high in comparison to other staff circulation patterns.

It is obvious that the placement of the reference collection in relation to the reference staff services is critical in saving the time and energy of both the staff and the public. This relationship is so strong that a difference of even 10 or 20 feet might mean the loss of literally thousands of hours of staff time and a great deal of public inconvenience when viewed in terms of the full life expectancy of the library building.

Looking further into the reference cluster, the catalog division has two very important relationships, one with the nonfiction collection (6.1%) and the other with reference staff services (3.9%). It is obvious that the catalog and the nonfiction collection should be placed as closely together as possible and certainly, at least, on the same floor. The public comprised the largest percentage of the traffic flow between these two divisions, while staff activity accounted for the bulk of the traffic between the catalog division and reference staff services.

The reference staff services division also has a significant relationship with the nonfiction collection (2.5%), which is based primarily on staff circulation patterns. It is understandable that the reference staff would spend a good deal of its time in the nonfiction collection helping the public find materials. In the Lincoln Library, the public uses the reference desk

as an information source, both when coming from and going to the nonfiction collection, accounting for the public's percentage (0.9) of the traffic flow.

Another important relationship, between the reference collection and the periodicals division (2.0%), is caused primarily by the public's interaction (1.7%). For the most part, this activity stems from the public's using the indexes and abstracts in the reference collection and subsequently pursuing the journal articles in the periodicals division. There is a high percentage of interaction between the reference staff services and the periodicals division (1.4%) for much the same reason.

The reference collection also has a significant relationship with the catalog (1.7%) and the nonfiction collection (1.4%). Much of the activity with the catalog comes from the public checking it after an incomplete search in the reference collection. More than twice as many public (15) travel between these two divisions as staff (7), and in both cases most of the individuals go from the reference collection to the catalog. The public will then often return to the reference collection or seek further information in the nonfiction collection. This activity shows that the reference collection and the nonfiction collection are even further related through the use of the catalog.

This concludes the discussion of the most important interactions within this activity cluster, except for one other relationship which is worth mentioning because of its unexpected lack of interaction. Surprisingly, the catalog shares only a 0.5% relationship with the technical services division.

During the data collection, the researcher observed that because of the distance between the two divisions, the technical services staff usually saved their work at the catalog for specific time periods and then did it in batches. Considering this, and the probability of future COM or on-line catalogs, the strength of this proximity priority is probably lessening even further.

The technical services division does have a significant relationship (2.4%) with the administrative services division. Even though there is some reason to believe that this relationship is functional, the proximity of the two spaces in the actual building is probably the primary reason for such a high value. This may be a prime example of how the existing building's design influences to some extent the outcome of the results. Unfortunately, this cannot be determined until another building which does not have the two divisions closely situated is studied.

It should be noted that the remaining divisions do have interaction values, but that they are of relatively minor significance in comparison to the ones already discussed.

Occupancy Analysis

Along with the data on the relative location of specified divisions of the library, the designer is also concerned with the use or occupancy levels of the divisions. Use or occupancy of a building space can be viewed in two ways: (1) the amount of time that the individuals using the space spend there, and (2) the frequency with which they visit the space. The difficulty in measuring these two parameters is based primarily on the difficulty in separating them.

The previous analysis concerning the activity relationships, or number of interactions between different divisions, is of little help because with respect to occupancy, it matters little where the individuals are coming from or going. What matters is simply how often they visit the individual spaces and how much time they spend in them.

The LSU methodology provides two forms of occupancy analysis. The first is a simple head count check for each division, and the second is based on "time spent by area," or amount of time spent in each division by the individuals observed circulating in the building. The first was deemed the most significant form of occupancy analysis because it provides the designer with the most useful information.

Head Count Analysis

The head count for each division is calculated by adding the individual head counts of both public and staff for each time an observation was conducted in a randomly selected division. Table 2 shows the head count statistics for the public, staff, and both combined. This table provides a breakdown of the total observations for each division, i.e., the total, lowest, highest, average and percentage of the number of heads counted in each category. From this table the designer can find a wealth of information concerning the "use" of the different divisions, because the table allows for easy comparison of the three subject categories. A particularly interesting application derived from this kind of data is the determination of the number of seats in a division and, to some extent, the type of seating, for the public and the staff.

Another and possibly the most important way of looking at the data is Table 3, which shows the sorted head count percentages for each division by each subject category. This allows a ranking of divisions by the number of people in them most of the time. It should be noted that the percentage computations for the staff, public and combined modes are presently based upon the individual subject categories, but that with a minor program alteration, the percentage computation could be based on the combined column only.

In the particular case of the Lincoln Library, this table shows that 18.1% of all individuals in the library were in the browsing division. This is the highest value in the combined column and would probably be quite surprising if it were not for the relatively large size (by administrative decision) of the browsing division in this library compared to other libraries, as well as its prime accessibility. Browsing is also the highest value for the public category (19.2%), but is quite low (3.7%) for the staff category. This demonstrates to the designer that most of the individuals in the division are public, with some staff interaction in helping the public use the browsing division. The designer could also see from Table 2 that the lowest number of combined individuals ever found in the browsing division was 4, the highest 23, and the average 11.6.

By looking at the public and staff categories, the designer could obtain similar information. For the public category, the highest number observed was 22 and the lowest 3, with an average of 10.3. For the staff category, the highest number observed was 4 and the lowest 1, with an average of 1.3. It is easy to see that this type of analysis could be performed for every division of the library, and indeed most designers would gladly do so if this kind of information were available in the building program statement. Unfortunately, it is not within the scope of this document to do this for each division because of space limitations.

TABLE 2. HEAD COUNT STATISTICS

AREA	OBS	PUBLIC					STAFF					COMBINED				
		TOTAL	LO	HI	AVE	PCT	TOTAL	LO	HI	AVE	PCT	TOTAL	LO	HI	AVE	PCT
PBE	56	43	1	1	.8	1.4	1	0	1	.0	.1	44	1	1	.8	.9
CCS	56	188	1	18	3.4	6.3	259	1	11	4.6	13.1	447	3	25	8.0	9.0
BRS	56	578	3	22	10.3	19.2	73	1	4	1.3	3.7	651	4	23	11.6	13.1
PMS	56	253	0	36	4.5	8.4	24	0	4	.4	1.2	277	0	37	4.9	5.6
CHS	56	305	2	17	5.4	10.1	113	1	5	2.0	5.7	418	1	19	7.5	8.4
RFS	56	6	0	3	.8	1.5	122	1	5	2.2	6.2	168	1	6	3.0	3.4
RFC	56	384	1	19	6.9	12.8	36	0	3	.6	1.8	420	1	20	7.5	8.4
CAT	56	127	0	13	2.3	4.2	31	0	3	.6	1.6	158	0	14	2.8	3.2
NFC	56	372	1	18	6.6	12.4	33	0	4	.6	1.7	405	2	20	7.2	8.1
FIC	56	83	1	8	1.5	2.8	4	0	2	.1	.2	87	1	8	1.6	1.7
PER	56	327	8	13	5.8	10.9	74	1	3	1.3	3.8	401	2	14	7.2	8.1
AVR	56	216	1	11	3.9	7.2	89	1	4	1.6	4.5	305	1	13	5.4	6.1
SPC	56	46	1	5	.8	1.5	180	1	6	3.2	9.1	226	1	10	4.0	4.5
ADM	56	23	0	11	.4	.8	197	0	14	3.5	10.0	220	0	14	3.9	4.4
EXT	56	0	0	0	0.0	0.0	43	1	3	.8	2.2	43	1	3	.8	.9
TCS	56	15	0	14	.3	.5	493	1	19	8.8	25.0	508	1	19	9.1	10.2
STS	56	0	0	0	0.0	0.0	180	1	9	3.2	9.1	180	1	9	3.2	3.6
STE	56	0	0	0	0.0	0.0	18	0	7	.3	.9	18	0	7	.3	.4

TABLE 3. SORTED HEAD COUNT PERCENTAGES

PUBLIC		STAFF		COMBINED	
BRS	19.2	TCS	25.0	BRS	13.1
RFC	12.8	CCS	13.1	TCS	10.2
NFC	12.4	ADM	10.0	CCS	9.0
PER	10.9	SPC	9.1	RFC	8.4
CHS	10.1	STS	9.1	CHS	8.4
PMS	8.4	RFS	6.2	NFC	8.1
AVR	7.2	CHS	5.7	PER	8.1
CCS	6.3	AVR	4.5	AVR	6.1
CAT	4.2	PER	3.8	PMS	5.6
FIC	2.8	BRS	3.7	SPC	4.5
RFS	1.5	EXT	2.2	ADM	4.4
SPC	1.5	RFC	1.8	STS	3.6
PBE	1.4	NFC	1.7	RFS	3.4
ADM	.8	CAT	1.6	CAT	3.2
TCS	.5	PMS	1.2	FIC	1.7
STE	0.0	STE	.9	PBE	.9
STS	0.0	FIC	.2	EXT	.9
EXT	0.0	PBE	.1	STE	.4

With this in mind, the remaining analysis will be limited only to those points which seem particularly significant or unusual.

The second highest head count percentage in the combined category is for technical services (10.2%). The reason for this is easily seen in the staff category, which shows a value of 25%.

Clearly, one-fourth of the total staff occupancy of the building is in the technical services division, with almost no public occupancy (0.5%).

The next highest division is circulation services with 9% in the combined column, which is somewhat more evenly divided between the public (6.3%) and staff (13.1%) categories. This division's ranking and statistics are very interesting in light of its importance to the library's organization. Table 2 shows that the lowest number of individuals ever found in the division was 3, with the highest being a whopping 25 (the second highest of all divisions, surpassed only by the public meeting room), and the average 8. When looking at the breakdown for public and staff, it can be seen that the lowest number of individuals ever observed for either category was 1, while the highest was 18 for the public and 11 for the staff. This is particularly significant for the designer concerned about good traffic circulation to, through and around this division. For example, it means that while most of the time there would only be 3 or 4 patrons in the division, it would on occasion have to accommodate as many as 18. The circulation space in front of the circulation desk would have to be designed to allow this flexibility of use without hindering traffic patterns to or from other parts of the library. This, unfortunately, is a shortcoming of many library facilities.

The next four divisional rankings for the combined column are very closely related: 8.4% for the reference collection, 8.4% for the children's services, 8.1% for the nonfiction collection, and 8.1% for the periodical services. It is primarily public occupancy which accounts for their ranking. The reference collection ranks second in the public column at 12.8%, followed by the nonfiction collection as 12.4%, the periodical services at 10.9%, and the children's services at 10.1%.

The last 11 divisions in the combined column share the remaining 34.1%, ranging from audiovisual and recreation services at 6.1% to the staff entry and exit division at 0.4%. Some librarians might be surprised as much by the low occupancy factors for various divisions (reference staff services at 3.4%, the general catalog at 3.2% and the fiction collection at 1.7%) as by the high factors reported above. The fiction collection's ranking is particularly puzzling until one discovers that most of the recent fiction (the last 5 years) is in the browsing collection and that the main body of the fiction collection is located in a physically remote part of the library.

With this kind of occupancy information and analysis infused into the programming and design process for every division, the designer can only produce a more functional and therefore higher-quality facility. All of this lends further support to the significance of basing planning criteria upon information gathered from factual behavioral activity in the library environment.

FURTHER STUDY

Future LSU Applications

This first application of the LSU methodology demonstrates that measurement of the library's functional requirements provides the designer with significant information which can be effectively utilized in the building program as functional design criteria. The

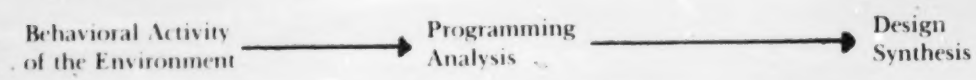
methodology is significant in that it is one of the first computerized library facility studies, but it is a modest beginning compared to the future utilization of computer techniques in library facility planning as well as other types of building planning and programming.

Since this study represents the analysis of only one public library, and it is acknowledged that the existing design as well as the size the library has an effect upon the results, further study is needed to produce a refined version of the methodology. This revised methodology should be based upon new research[5] and the experience gained in this first application of LSU. Many new factors could be added to the methodology, and eventually, through the study of a number of buildings, a general spatial relationship model might be developed. Part of the output of this new planning tool could include a facility efficiency index. This index could be used by the library profession as a performance standard, and by the architect as a design tool to establish functional accessibility criteria by which alternative design solutions could be evaluated during the design phase.

Future applications of a modified LSU methodology could not only be performed on several different sizes of public libraries, but it also could potentially be further modified for use in other types of libraries. The next immediate logical step is to apply a refined methodology to a number of public libraries in the field which are recognized by the profession as being highly functional facilities. Libraries named on the *Notable Buildings List*, which has been recently assembled by ALA's Architecture for Public Libraries Committee, along with past ALA-AIA Design Award winners, are among those which could be considered potential candidates for future applications.

If the new methodology is applied to several different sizes of libraries and monitored over a longer period of time, then the information gained could be recycled back into the building programs of facilities currently in the design phase. This tool would not only provide the library profession with more effective physical facilities, but would also provide considerable efficiency in terms of time and money during the planning, programming and design process.

The overall concept implicit throughout this study is that high-quality design for library facilities is dependent upon comprehensive architectural programming which provides a measured, in-depth behavioral activity analysis of the environment within the building type. It is the analysis of the behavioral activity in the environment of the library/information center that provides the very foundation for the *functional* planning criteria. These criteria are the basis of the total planning process which progresses from behavioral observation, through the programming phase, to the design solution:



The Electronic Library Facility Planning Environment

In a similar progression configuration is the planning process for electronic libraries:

LSU ⟶ **LAPISNET** ⟶ **CAD**

Library Space Utilization

Library Architectural Programming Information System Network

Computer Aided Design

In this context, the LSU methodology provides hard physical data which when collected and analyzed can be used in program form as input for a CAD system. At present, there is no CAD program that has been written specifically with libraries in mind, but the profession could benefit if one were developed, or an existing one utilized, in conjunction with a modified LSU.

There are several CAD programs of a general nature already in existence (CORELAP, ALLEP, CRAFT, etc.) and others are currently being developed. CAD programs utilize input data to produce plotter-output drawings which "pack" individual spaces together by using quantitative activity relationships. This means that those spaces that have a high interaction percentage will be located next to or very close to one another.

It is acknowledged that simple plotter-produced line drawings showing the basic spatial relationships of a building type are a long way from a computer-designed facility, but progress is being made in finding other methods that will allow the computer to be more effectively utilized as a design tool. There has been great interest in past years in three-dimensional graphic representation of internal spaces, which show not only the dimensions of the spaces, but also windows, doorways, equipment and furniture layout. As these programs become more sophisticated, generally available, and accepted by the architectural profession, they will greatly enhance the quality of the design process as well as the facilities produced.

Although library facilities are not currently in the forefront, certain building types have already received intensive computer-assisted study. The most notable among these are hospital facilities.[6] Industrial plant layout has also been submitted to considerable computer analysis as reported in one of the more comprehensive works on the subject, *Facility Layout and Location* by Richard Francis.[7] As time passes and the cost of computer usage continues to decline, it is likely that there will be even more research and development not only in the area of CAD, but also in computerized specification writing (Masterspec, Comspec, etc.) and in computer-assisted architectural programming.

It is this last area which may well have the most significant impact on the future planning of library facilities. Many prominent architectural firms are beginning to use "office automation" equipment to assist in their architectural progamming activities. In addition to this, information systems dedicated entirely to architectural programming for specific building types will begin to come into existence in the near future.

LAPISNET, the Library Architectural Programming Information System Network, is one such electronic architectural programming tool for libraries. The system will help to bridge the interdisciplinary gap between the professions of architecture and library/information science. LAPISNET is an electronic text-generating, processing, storage, retrieval and production system dedicated to the goal of providing an optimal display of the essential

design criteria for library facilities. In short, it is an electronic "window" through which members of the library facility project team may view that information which will improve their decision-making and thus optimize their potential positive contribution to the planning process.

The utilization of LAPISNET, as well as the other electronic tools mentioned, will not only increase the overall access to the necessary information desired in the planning process, but it will also increase the speed of access by reducing the turnaround time for data collection, transmission, display and printing. It is hoped that the result will give the profession and the public better-quality physical facilities for libraries and information centers.

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